Capstone Design Project: Developing the Smart Arm Chair for Handicapped People

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Abstract

The senior students of KoreaTech are, as their capstone design project, given to consider that the smart arm chair for the handicapped people is to be designed and developed. The smart arm chair is designed to control the direction of movements of chair and the cooling and heating of the chair seat. The sensors being attached to the chair are used to detect the movements of human body and to control the chair. As the person approaches to the chair, the chair is being rotated to welcome him/her and will make the person be more easily seated. The current temperature of the seat being compared with the desired temperature will operate the fan for heating or cooling the people by clicking the cooler or heater. The smart chair being developed will be suitable for the feeble old person and the person using the cane and the other assistance. The students learned about the signal processing of sensors, microprocessor application and programming, mechanical analysis, the temperature control and system design process and capability through their team efforts. Students are grouped to develop the creative idea from the beginning stage based on brain storming process and the objective of the capstone design project was finally derived (talk about team work not group). Their experience by participating at the capstone design project developing the smart arm chair give senior students their professional achievements, which must include the soul of entrepreneurship.

Keywords: *Capstone Design Project, Smart Arm Chair, People Having Special Needs, Development Process, Entrepreneurship*

1. Introduction

1.1 Aging society and silver industry

According to the data from the National Statistical Office of the Republic of Korea in 2013, the number of the elderly people has increased by 12.2% of the total population, revealing a trend of a steady annual increase. It is predicted that the ratio of the elderly will amount to 37.4% of the total population in 2050, just 36 years later. Especially, the ratio of the so-called super-aged people, more than 85 years old, is expected to make a significant increase from 0.9% of the total population in 2013 to 7.7% in 2050 [1]. Such an increase in the number of senior citizens has brought about a change in their consciousness and a new phenomenon of planning to save money for their later years, so that the so-called silver industry targeting the elderly started to have developed rapidly in recent years. The aging society is a common phenomenon in the whole world as well as in Korea, and a lot of countries started to pay more attention and provide great supports for the welfare of the aged.

1.2 Increase of the disabled

WHO reported that 15.6% (approximately 785 million) of the world population in 2002-2004 and 19.4% (978 million) in 2000-2004, over 15 years of age, would be referred to as the disabled. On the basis of the World population estimates projected for 2010, the number of the current disabled people would be estimated more than a billion. A comparison is easily made in the prevalence of disability, 8.9% of the population from 18 to 49 years of age, but as high as 38.1% at 60 and more years of age. Likewise, the percentage of the disabled shows an increase in proportion to people's aging process, so that a variety of technologies needed to assist the aged and the disabled have developed [2-3].

1.3 Goal of the capstone design project

The goal of the capstone design project was for students to learn knowledge in technological and pedagogical areas. The knowledge in the engineering area included 3D tool or control, numerical analysis, temperature control, C-language and sensor signal processes. The knowledge in the pedagogical area included build-up of ethical awareness for the disabled, co-operation and communication skills and entrepreneurial mind-set.

2. Organization of the project team

As shown in Table 1, the project team consisted of five people. The project team divided the project largely into two stages. The first and second stages were performed by hardware and software sub-teams, respectively. Specifically, the hardware sub-team designed a product, selected its materials and analyzed its system. On the other hand, the software sub-team made various signal controls for motors and sensors. The hardware and software sub-teams carried out their tasks separately, but had regular co-operative team meetings under the direction of a team leader to share all the information on the progress of their tasks.

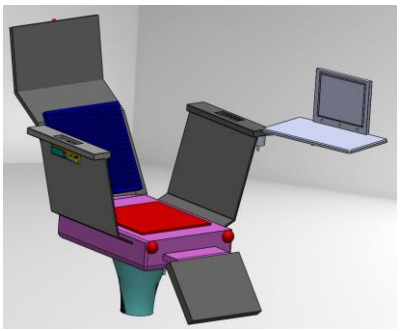
Table 1. Team organization and members

member		A(leader)	B	C	D	E
HW	design/ selection	○	○			
	analysis			○		
SW	sensor control				○	
	motor control					○

Without the general meetings, they would not have avoided a lot of conflicts or mistakes as there was no smooth job co-operation between the hardware and software sub-teams. All the team members participated in free and open discussions and shared members' opinions about the project during brainstorming sessions [4]. They also made collective decisions through discussions on the progress of the project.

3. Design and analysis

Table 2. Design of the smart arm chair and analysis on its operations

step	idea concept
designing a structure of the smart arm chair	

For the convenience of a user, a smart arm chair was designed to control temperature and automatically rotate toward a previously identified position of the user. Cooling fans and heating coils were operated to control and set an optimum level of temperature for the user. Once the user sat on the chair, it was necessary to stop a person recognizing sensor from working. Therefore, a clutch was attached at one side of the chair to get disconnected from the motor, so as to prevent automatic rotations and allow the user to move the chair readily.

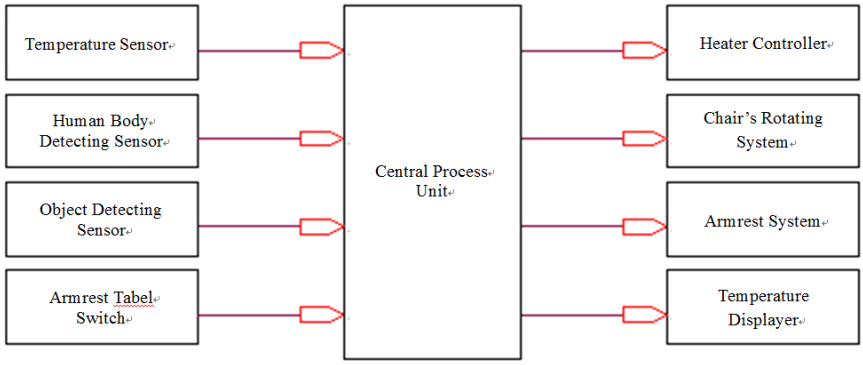


Figure 1. System block diagram.

Central control

The structure of the smart arm chair was constructed as followed. A central processing unit, Atmega128, was used to control a driving system with the signals generated by respective sensors and buttons.

A temperature sensor was used to monitor the peripheral temperature on the real time basis to operate a heater controller and a temperature displayer. Instead of the automatic temperature control, the level of temperature could be controlled by a user as the user would desire by turning on an armrest table switch.

A heat-sensitive infrared sensor, RE-0003, was used as a human body detecting sensor to detect appearance of a person.

A sensor called BA2M-DDT, which could measure the distance of 2.5M, was used as an object detecting sensor to make the chair detect an approaching human body or other things and stop toward the direction where the human body or the others would be approached

A simple armrest table was to be operated by the switch control, and a limit switch was used to stop exactly at a position where the table was expected to be rotated.

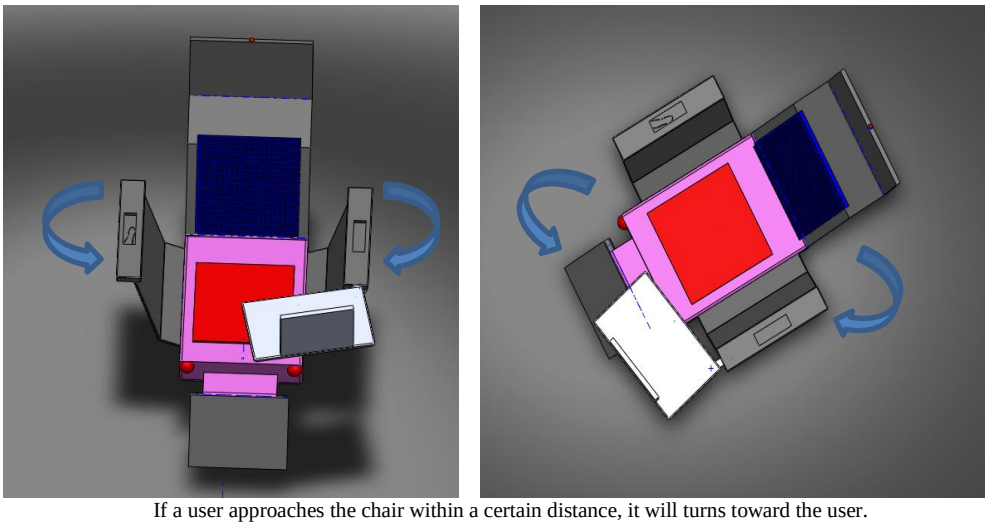
Control of rotation

Figure 2. Position of sensors and unit

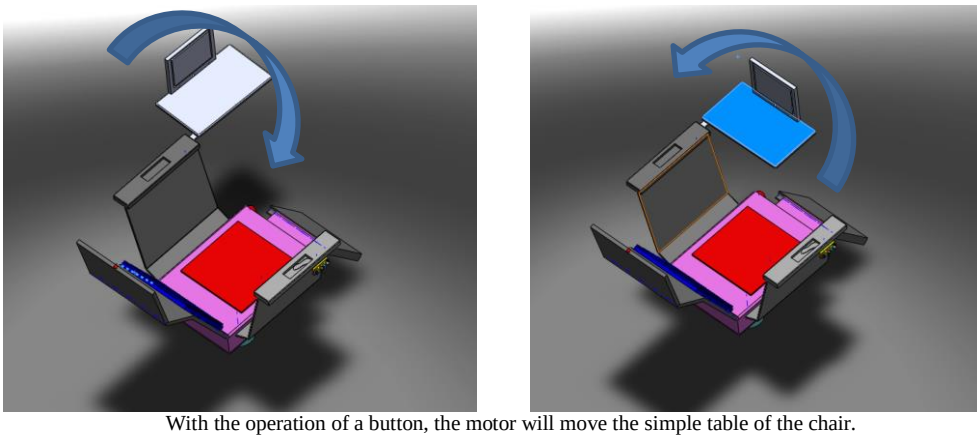
Sensor 1 was used to check the existence of a user and the contact with the clutch.
Sensor 2 was used to determine the position and movement of the user and the contact with the clutch.
Sensor 3 was used to check whether the user was sitting on the chair or not.

Problem during design process some difficulties were observed in designing the chair: With using only one human body recognizing sensor, there might have been a case that it would fail to recognize a person approaching from a direction opposite to the chair while it turned at the other direction.
Resolution as a result of discussion: Two sensors are attached at both directions to fully cover

the range of the rapid detection of an approaching person.
Motor torque is set at 30RPM, based on the average weight of an adult, 80Kg, 80 * 0.2/1 = 16kgf • m



If a user approaches the chair within a certain distance, it will turns toward the user.



With the operation of a button, the motor will move the simple table of the chair.

Figure 3. Operational simulations of the smart arm chair

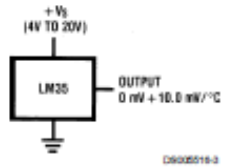


FIGURE 1. Basic Centigrade Temperature Sensor
(+2°C to +150°C)

Figure 4. Temperature measuring sensor LM35

Control of temperature

A temperature measuring sensor attached to the chair was to detect its peripheral temperature for heating and cooling within an effective range of temperature. While the heating coils of the heating seat were to be turned on at under 18 degrees of Celsius, the cooling fan was to be turned on at over 22 degrees of Celsius.
The heating coils and cooling fan were assembled to control the temperature of the chair for the user. The heat lines were laid in the seat of the chair [5].

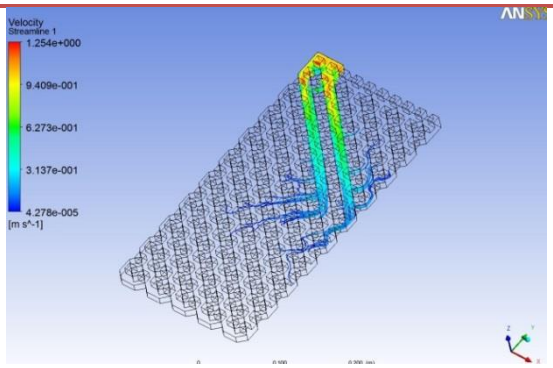


Figure 5. The cooling fan operating at 1m/s

As the cooling fan was directly designed, the air blowing condition was analyzed as followed. Under the condition that air was blown in its symmetrical direction, an analysis was made on half of the chair. When air was blown by the cooling fan at 1m/s, it was confirmed that the air failed to be blown equally and smoothly across the whole back of the chair.

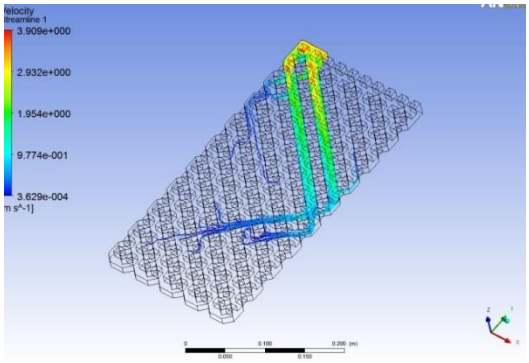


Figure 6. The cooling fan operating at 3m/s

When air was blown at 3m/s, it was confirmed that the air was blown better, if just a little, to the bottom of the whole back of the chair. In general, the air might be blown well across the back of the chair in proportion to the air blowing intensity of the cooling fan. However, in consideration of the noise generating from the fan, its air-blowing speed was set at 3m/s [6-7].

4. Steps of manufacturing the smart arm chair for the disabled

In order to manufacture the smart arm chair, a chair was reformed under the direction of the team leader.

4.1 Chair rotation controller

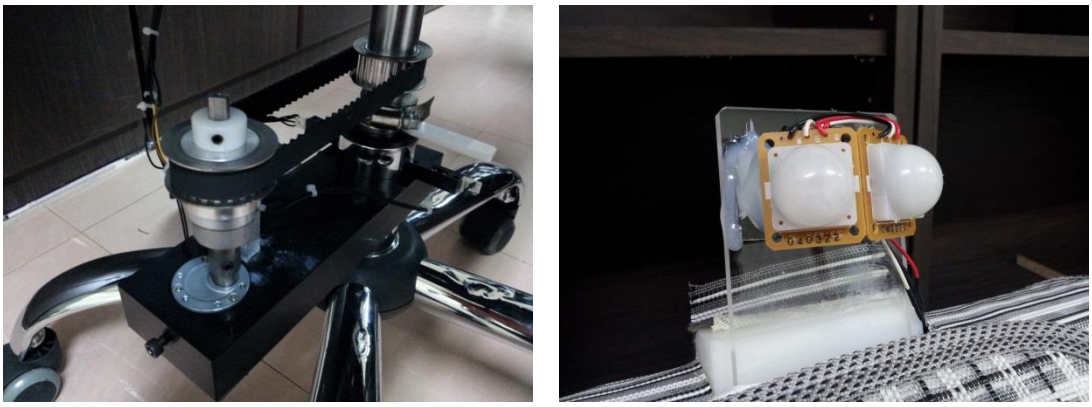


Figure 7. Rotation clutch & sensor controller and detecting a human body Sensor

The clutch was assembled on the chair to design a system which would prevent the motor from working when a user sat on the chair. The human body detecting sensor was mounted at the neck supporting part of the chair to easily check whether the user was seated on the chair.

4.2 Simple table rotation controller

Figure 8. Table rotation driving pictures

KDG2629 was used as a driving motor and designed to rotate at DC 12V with the driving speed of 20RPM.

4.3 Temperature sensor controller

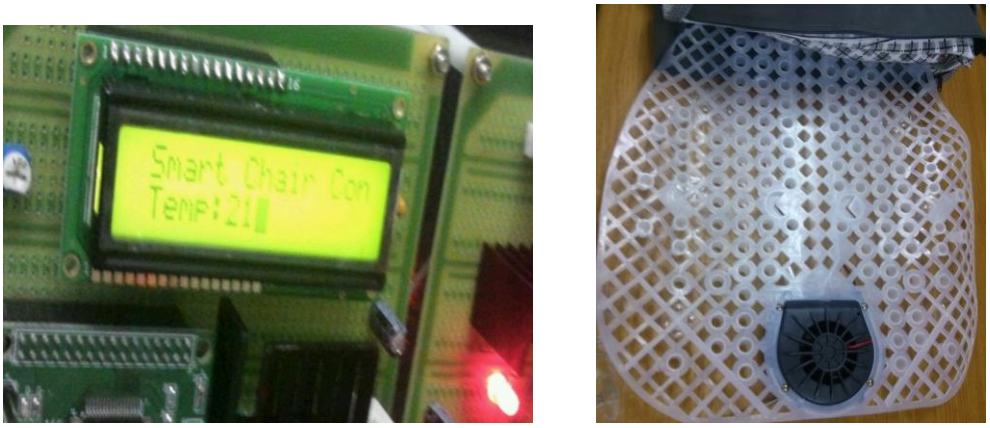


Figure 9. Temperature checked with LCD and fan additionally mounted at the seat

A sensor was attached at the seat to measure the outside temperature, and the current temperature was checked with LCD. A real-time temperature monitoring system was constructed to control temperature at its desired level as the user would check the current temperature of the chair and manually set it at a target temperature.

4.4 Results of the capstone design project

Figure 10. Smart arm chair completely manufactured as the final product of the capstone design project

5. Conclusions

Students took an issue, how to make an actual product which could benefit the ever-changing global society at present and in future, into serious consideration. In the course of this project, they learned real-time signal processing and microprocessor of sensors, programming, mechanical analysis, temperature control and system designing processes.

This project needed a teamwork, which made all the team members play their own parts and improved co-operation and open discussion skills. Students derived a creative idea from the brainstorming sessions of the team, and successfully achieved the objective of the capstone design project. In order to make a final product of their idea, they directly experienced all the steps, from designing a product according to their creative idea to selecting materials and simulating the operations of the product. Thus, this project gave them an actual chance to put their engineering studies into practice and obtain an entrepreneurial mindset.

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